

SCYPHOMEDUSAE *

FROM THE ARCTURUS OCEANOGRAPHIC EXPEDITION.

BY HENRY B. BIGELOW.

Museum of Comparative Zoology.

(Figs. 180-184 incl.)

SPECIES.

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Order CORONATA.

Family PERIPHYLLIDAE.

Genus *Periphylla*.

I believe it probable that all the *Periphyllas* yet described will eventually prove nothing more than contraction-phases or racial variants of a single species, the cosmopolitan, but bathypelagic *P. hyacinthina*, Steenstrup. Recent studies (Bigelow 1909, 1913, Broch, 1913), and especially Broch's (1913) examination of the very large series collected by the *Michael Sars*, in the North Atlantic, have resulted in the definite union of *P. dodecabostrycha* with *P. hyacinthina*. Broch still retained Haeckel's name *regina* for a few of these specimens, in which the floor of the subumbrella was evenly rounded, with no trace of the so-called "stiel canal," and in which the pedalia were more globular, and less oval, than is usual among *P. hyacinthina*. But the present series contains two specimens precisely intermediate between *hyacinthina* and *regina* in these respects, for while they lack "stiel canal," their pedalia show the usual *hyacinthina* conformation; consequently the combination of characters used

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by Broch does not suffice to separate *regina* from *hyacinthina*. Final decision as to whether *regina* is, in fact, separable from *hyacinthina* in any other way can be reached only after larger series of specimens with the globular pedalia, supposedly characteristic of it, have been examined. The *Arcturus* series are all typical *hyacinthina* in this respect.

Periphylla hyacinthina, Steenstrup.

Periphylla hyacinthina, Steenstrup, 1837.

Synonymy, Mayer, 1910, p. 544-546 (incl. forma *dodecabostrycha*).

Station 7, 3000-0 meters, one fragmentary specimen; about 25 mm. in diameter.

Station 50, 1200-0 fathoms; one excellent specimen, about 40 mm. in diameter by 72 mm. high.

Station 59, 600-0 fathoms, 1 specimen, about 55 mm. in diameter.

Station 61, 600-0 fathoms, one about 20 mm. in diameter by about 20 mm. high, and fragments of another very large one.

Station 66, 600-0 fathoms, one about 95 mm. in diameter by 110 mm. high.

Station 68, 600-0 fathoms, fragments.

Station 74, 450-0 fathoms, one specimen, 17 mm. in diameter. 600-0 fathoms, 8 specimens, 17-85 mm. in diameter, and fragments of others. 749-0 fathoms, 2, fragmentary, about 40-50 mm. in diameter.

Station 84, 500-0 fathoms, 2, of 18 and 20 mm. diameter.

Station 100, 1098-0 meters, one specimen, about 30 mm. in diameter by 36 mm. high; 2192-4 meters, 3 specimens, 22-30 mm. in diameter.

Station 105, 500-1 fathoms, one, about 17 mm. in diameter.

Station 107, 700-1 fathoms, two, respectively 14 and 20 mm. in diameter.

Station 113, 800-0 fathoms, 1 specimen about 20 mm. in diameter, and 3 others of the following dimensions:—22 mm. diam. by 20 mm. high; 22 mm. diam. by 31 mm. high; 25 mm. diam. by 40 mm. high.

Also, 2 other specimens, unlabelled, one about 45, the other about 110 mm. in diameter.

The series illustrates various intermediates from specimens with the bell lower than broad, to others in which it is much higher than broad, as the listed measurements show. And one (station 50) is of very high, pointed outline. All but two show a stiel canal—longer or shorter. All specimens larger than about 35 mm. in diameter, and three of the small specimens, of 18, 20 and 22 mm., are typical *hyacinthina* in color, with the gonads entirely masked by the dense pigmentation. Most of those smaller than 30 mm. are of the *dodecabostrycha* type, in this respect, with only the central portion of the gastro-vascular system pigmented, so that the gonads show through, when viewed from without. And three specimens, of 17, 20, and 22 mm. respectively, are best described as intermediate in color, their gonads being partially concealed. On the whole, then, the *Arcturus* series shows an extension of the pigmentation with growth, corroborating earlier studies. But Broch (1913) has found that this progressive pigmentation is not only complicated by wide individual

variation, but also by a definite correlation between the amount of pigmentation and the depth at which the medusa lives; among the very extensive series collected by the *Michael Sars*, heavily pigmented specimens were most plentifully represented in hauls from 600 meters or deeper, the paler ones (*dodecabostrycha* type) in shoaler hauls.

The present series are all from hauls so deep that they throw no light on this question. The failure to take any in shoal hauls is, however, interesting, as further confirmation of the thesis that *Periphylla* never normally swims upward to the zone of strong illumination in Tropic seas, contrasting with its not exceptional occurrence right at the surface in arctic and subarctic latitudes (Kramp 1913, 1924).

Most of the *Arcturus* locality records are from the Gallapagos-Cocos I. region in the Tropical Pacific (Stations 50-84), where this medusa has already been found widespread (Maas, 1897, Bigelow, 1909). The rest are from the Atlantic:—Sargasso Sea to the southeast of Bermuda (Stations 7, 14); vicinity of Bermuda (station 100); and continental slope in the offings of Cape Hatteras (Station 107) and of New York (station 113). With previous records, these show *Periphylla* as cosmopolitan over the western Atlantic as it is in other parts of the ocean, and in the Mediterranean (Kramp, 1924, p. 40, Chart X).

Family NAUSITHOIDAE.

Genus *Nausithoë*.

As now recognized, the genus *Nausithoë* includes all those members of its family in which there are 8 tentacles and 8 sense organs; 16 marginal lappets; and 8 gonads primarily adradial, whether or not these organs approach one another in the interradii, or even coalesce, when mature.¹

Recent authors have devoted considerable attention to *Nausithoë*; nevertheless it is not yet possible to determine how many true species are actually represented by the various forms which have been named. In part this is due to the paucity of specimens of the various bathypelagic *Nausithoës* which have yet been examined; but still more to the intergrading nature of the characters by which the several species are supposed to be separable. A final revision of the genus can not be expected until some one is able to study the range of variation of such characters as the sculpture of the exumbrella, the degree of pitting of the central disc, the shape of the marginal lappets, and the outline and size attained by the gonads at maturity.

As matters now stand, the known members of the genus fall into three subdivisions; the *punctata* group, characterized by the

¹ See Broch (1913) for a general survey of the limits of the genus.

presence of ocelli (with lens) and by gastric filaments in continuous series: the *rubra* group with the gastric filaments similarly arranged but lacking ocelli; and the *albatrossi* group, with the gastric filaments in clusters (it is not known whether *albatrossi* has ocelli).

In the first group, besides *N. punctata*, fall *N. Challengeri*, Haeckel, *N. picta*, Agassiz and Mayer, and *N. limpida*, Hartlaub, all of which may finally prove to be variants of the one species, *N. punctata*. *N. picta*, in fact, differs from *punctata* only in the progressive development of its gonads and in its more brilliant pigmentation. *N. challengerii* (2 specimens seen only) is separable from *N. punctata* only by the faint radial furrows which Haeckel records as marking the margin of its central disc, and by more prominent exumbrel sculpture, characters which have proved extremely variable in related medusae. And Hartlaub's (1907) *N. limpida* agrees in every respect with *punctata* of equal size, except that the median members of each group of gastric cirri arise from a centripetal, radial fold of the dorsal wall of the stomach.

The second group, includes *N. rubra*, *N. atlantica* and *N. globifera*. The interrelationships of the first two are discussed below (p. 500). All of the characters by which Broch (1913), separates *globifera* from *atlantica*, are relative: e. g. relative development of the gonads at different sizes; prominence of the exumbrellar sculpture; degree of arching of the bell; presence or absence of exumbrel nettle spots; precise length of the small lappets which bear the rhopalia; and pigmentation. Since most of these same characters have proved highly variable in the related genera *Periphylla* and *Atolla*, both of which also show wide individual variation in size of bell relative to stage of development of the gonads (perhaps depending on nutrition), it is not safe to assume greater stability for the bathypelagic members of *Nausithoë*. It therefore seems likely that *rubra*, *atlantica* and *globifera* will finally prove to represent extreme variants of the one species, though no definite pronouncement can be made until much larger series (and series in a better state of preservation) can be examined.

Nausithoë punctata, Kölliker.

Nausithoë punctata, Kölliker, 1852, p. 323.

Synonymy, see Bigelow, 1909, p. 35; Mayer, 1910, p. 554.)

A single specimen of this well-known species, about 5 mm. in diameter, was taken among the Gallapagos, Station 49, 1° 39' S; 89° 30' W; depth not stated.

This specimen (an adult with large gonads) is not in good enough condition to add anything to the previous accounts of this well known species. I may point out, however, that the gonads are all spherical, and equidistant, and that the gastric filaments of each bundle arise in a single straight row, these being two of the distinguishing characters of the species. The specimen is too much damaged to show the state of the exumbrellar warts.

N. punctata was to be expected in Gallapagos waters, having been recorded from off the west coast of Mexico; from the vicinity of Easter Island; from Japanese waters; at Tonga and Fiji in the west Tropical Pacific; and from various localities in the Indian Ocean (Agassiz and Mayer 1899, 1902; Browne, 1916; Bigelow 1904, 1909, 1913).

The south seas representative of the species was described as a distinct variety, *pacifica*, by Agassiz and Mayer. And this name is retained by Stiasny (1919) for specimens from the West and East Indies. But the supposed differences—slightly paler coloration and frequent absence of spots on the exumbrella in the var. *pacifica*—are so slight, and so variable, that my own examination of specimens from the Western Atlantic, West Indies, Mediterranean, Eastern Tropical Pacific, Fiji, Japan and the Maldives, gives no sound ground for distinguishing a Pacific or an Indian race of this wide ranging species, as distinguished from an Atlantic. Mayer (1910), too, and Browne (1916) recognize only the one race.

The range of *Nausithoë punctata* thus includes the tropical and subtropical belts of all three great oceans; also the Mediterranean.

Nausithoë rubra Vanhöffen.

Nausithoë rubra, Vanhöffen, 1902, p. 30, taf. 1, figs. 4, 5; Bigelow, 1909, p. 36, pl. 12, fig. 6.

?*Nausithoë atlantica*, Broch, 1913, p. 10, pl. 1, figs. 1-4.

One specimen, about 8 mm. in diameter, in fair condition; station 45, Lat. 0° 20' N.; Long. 90° 10' W., near the Gallapagos Is.

This specimen adds little, except in the way of confirmation, to the earlier accounts of the species (Vanhöffen, 1902; Bigelow 1909). It is, however, interesting as illustrating a more advanced stage in the growth of the gonads, and as affording an opportunity to test the validity of the characters by which Broch (1913) separated his *N. atlantica* from *N. rubra*.

Fortunately the rhopalia are in good enough condition to show that ocelli are lacking, as is characteristic of the species *rubra*, and of the other bathypelagic members of the genus (p. 498). The characteristic arrangement of the considerable number of gastric cirri (approximately 100) in a single continuous series, along the four sides of the stomach, is also easily traced.

In Vanhöffen's (1902, P. 30, Pl. 1, figs. 4, 5) original account and illustrations, the gonads are shown as spherical and equidistant; with large eggs.² The present example shows, however, that this is not the final state. Here the gonads are relatively much larger, and have so broadened at the base that they have not only taken on a roughly shield shape, but have come close together in the perradii as well as in the interradii. It is also interesting to find considerable variation in the shapes of the individual gonads in the single individual, for

² In the Eastern Pacific specimens (Bigelow 1909), the gonads were destroyed.

while seven are regularly shield shaped, and broadest at the proximal ends, one is much narrower, oval, and nearly twice as long as the rest. This specimen, like Vanhöffen's, is apparently a male, surface views of the gonads showing sperm-follicles in various stages of growth, from small to large, much as in Haeckels (1881) figures of *N. Challengeri*.

The *Michael Sars* series of *N. atlantica* illustrate a still more advanced state, for while the gonads (more or less shield shaped as in the present specimen) are separated by distinct spaces in the perradii, some of the pairs are in close contact in the interradii in adults (Broch 1913, Pl. 1, Fig. 2).

The marginal lappets corroborate Vanhöffen's account, by their great length, and narrow, pointed outlines. And each rhopalium is situated on a very short subsidiary lappet, at the bottom of the deep marginal notch which indents the margin, alternating with the tentacles. These small rhopalar lappets are also to be seen on Vanhöffen's beautiful pictures of *N. rubra*. Broch (1913) described corresponding structures as one of the distinguishing features of *N. atlantica*. But they are nearly as large in the present specimen as he shows them for *atlantica* (Broch, 1913, Pl. 1, Fig. 2); and only a little, if any larger than Vanhöffen shows them, in his original figures of *rubra*. Thus a gradation exists, in this respect; whether due to regional, to racial or to individual variation, forbidding the use of this feature as a specific character, unless much larger lappets should be found on some species of the genus, as yet undiscovered. In short, there seems no more warrant for separating *N. atlantica* from *N. rubra* on this ground, than on the size and exact conformation of the gonads.

A supposed difference between the two species, lies in the precise conformation of the pedalia, a character the diagnostic value of which can be tested only by the comparative study of more extensive and better preserved series. According to Broch (1913) *N. atlantica* is separated from *N. rubra* by (*inter alia*) tentacular pedalia longer, but less prominent, than the rhopalar, though the members of these two series are almost equally broad. But, so far as there is any information to the contrary, this may equally have been true of the original specimens of *N. rubra*, for Vanhöffen (1902, p. 30) informs us merely that "Ringfurche und Pedalien sind wohl ausgebildet," while his illustrations do not show the exumbrellar sculpture at all. Unfortunately no one of the Eastern Pacific specimens of *N. rubra* was in good enough condition to show the precise conformation of the pedalia, though the existence of these gelatinous prominences was obvious (Bigelow, 1909, P. 36). On the present example the ring furrow is well marked, and the pedalia in good enough condition to show that the members of the two series, tentacular and rhopalar, are approximately of equal size. Unfortunately the margin of the exumbrella is not in good enough condition to allow the distal outlines of the pedalia to be traced with certainty. As far as can now be seen, the tentacular and rhopalar series appear to be of about equal length, merging insensibly into the general contour of the marginal zone at their outer ends. But, in life they may have been more abruptly rounded.

When we remember how subject these gelatinous structures are to damage in the net, and the variability of the sculpture of the exumbrella in the related

genus *Atolla* (p. 505), it seems at least questionable whether the precise outline of the pedalia on preserved material can be given specific value here.

I have not been able to determine, definitely, whether the rhopalia of the *Arcturus* specimen were carinate. But re-examination of the rhopalium of an Albatross specimen of *N. rubra*, photographed in my earlier account (1909, Pl. 12, Fig. 6), proves that it is provided with an exumbral carina, such as Broch describes for *N. atlantica* and for *N. globifera*; Hartlaub (1907) for *N. limpida*.

This leaves, as a definite alternative character, between *rubra* and *atlantica*, only the presence or absence of exumbral nettle warts on the central disc. According to Vanhöffen, (1902, P. 30) the latter is "grubig punktiert" with such warts in *N. rubra* (his figures do not show this), while, in *N. atlantica* Broch (1913) describes the disc as smooth. Here, again, the Eastern Pacific specimens of *rubra* fail us by their fragmentary state. On the *Arcturus* specimens no warts are to be seen. And as the central disc is in good condition, it is safe to say that this was smooth in life.

The relationship of this specimen to *N. rubra* and to *N. atlantica* may, then, be summarized as follows:—with *N. rubra* it agrees closely in general conformation and in the shortness of the rhopalar lappets: with *atlantica* in the smoothness of the disc. It is intermediate, to some degree, between the two, in the size and conformation of the gonads. And it agrees with other members of the genus, and differs correspondingly from *N. atlantica*, in the conformation of the pedalia. In short, it forms a connecting link, thus making it probable that examination of larger series, in better condition and in various stages in growth, will prove *N. atlantica* to be, at most, a variant of *N. rubra*.

N. rubra (under this name) is already known from the Indian Ocean, from the Humboldt Current near the coast of Peru, near the Gallapagos, and between that group and Panama; likewise off the mouth of the Congo in the Tropical Atlantic. Its variant *N. atlantica* has been recorded from the Eastern Atlantic between the Azores and Europe. Thus *N. rubra*, like other bathypelagic Medusae, will probably prove world wide in the Tropical and Subtropical belt, if not in higher latitudes as well.

Family ATORELLIDAE.

Genus *Atorella*.

The collections made by the Valdivia Expedition contained an interesting new coronate medusa, with six tentacles and six rhopalia, instead of a multiple of four, which Vanhöffen (1902) christened *Atorella*. The one specimen (in poor condition), had only four gonads intact, a numerical nonconformity, between sex and marginal organs so unexpected, and entailing so irregular a radial relationship between them, that Vanhöffen thought it probable that the specimen had either lost two of its gonads, or was a sport. But the discovery of a second specimen, in the *Siboga* collection, by Maas (1903); and of 3, representing still another species of this *Atorella* type (*A.*

vanhöffeni) by the *Albatross* (Bigelow, 1909), proved this relationship between gonads, tentacles and rhopalia to be normal, and therefore a sound generic character.

The *Arcturus* collection now adds to the coronate series a form resembling *Atorella* in the number (6) of its tentacles and rhopalia, but differing from it in having six gonads instead of four, so that the gonads conform to the marginal organs in their radial symmetry, rather than to the stomach. Unfortunately (as is so often the case when oceanic medusae are first discovered), there is

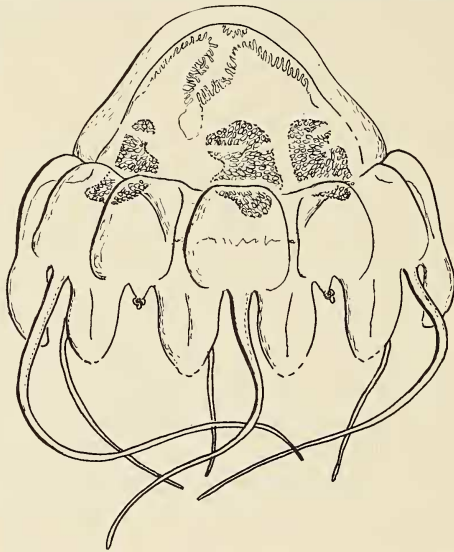


Fig. 180. *Atorella arcturi*, sp. nov.; side view of type specimen, 15 mm. in diameter.

only one specimen; and this one not in the best of condition. And radial reduplication, or suppression, is so common a variation among medusae (as in *Aurelia*) that this one specimen is best regarded as an aberrant *Atorella*. Specifically, however, it appears distinct from either of the members of the genus previously seen.

***Atorella arcturi*, sp. nov.**

Station 59, near Cocos I., Lat. $3^{\circ} 52' N.$, Long. $86^{\circ} 43' W.$ 600-0 fathoms. One specimen.

The specimen is in good enough condition to show the general form, and the more important anatomical characters. But most of the marginal lappets are broken off, and the subumbrella and manubrium damaged.

In general form (Fig. 180) this medusa is moderately domed, the central disc about 15 mm. in diameter, the marginal zone about 7-8 mm. broad, including the lappets. The exumbrel sculpture is of the usual coronate type, with well marked coronal and pedal furrows, the tentacular pedalia somewhat wider than the rhopalar. As far as can now be seen the central disc is smooth, with no trace of radial furrows; nor are any nettle warts to be seen. But as the specimen was evidently much rubbed in the net, these latter structures may have been lost. There is one marginal lappet between each tentacle and the neighboring rhopalium—a total of 12, just as in *Atorella*.³ Such of the

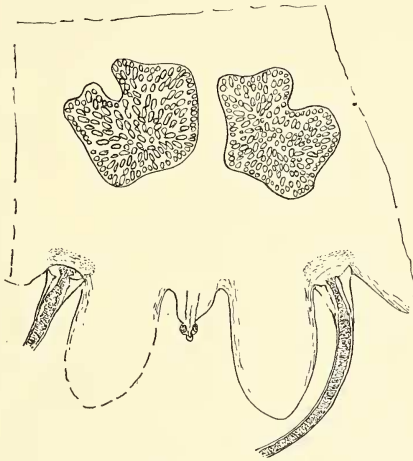


Fig. 181. *Atorella arcturi*; suboral view of part of marginal zone, showing two gonads, tentacles and rhopalium.

lappets as are in good enough condition to indicate their normal outline are longer than broad, rounded at the tip and somewhat broader distally than at the base; longer and narrower than in *Atorella subglobosa* or in *A. vanhoeffeni*; but suggesting the lappets of the genus *Atolla*. The tentacles, all but one of which are still intact (the sixth is broken off near the base) are longer than the bell-diameter, tapering evenly to narrow tips, with no trace of the terminal knobs characteristic of *Atorella vanhoeffeni*. And as they are tolerably well preserved, this may be accepted as their natural state.

The tentacles, lying in the radii of the gonads, are, 2 interradial, 4 adradial with reference to the stomach.

The rhopalium, alternating with the tentacles, and gonads, are 2 interradial and 4 perradial. Each rhopalium is situated at the tip of a small triangular

³ Maas' (1903, Pl. 3, Fig. 6) illustration of *A. subglobosa* suggests twice as many. But this was evidently the result of mutilation, all the lappets being torn short off at the base; and such parts of the margin of the present specimen as have lost the lappets, give a similar picture.

lappet of the margin (Fig. 181) intermediate, in length, between those figured by Broch (1913) for *Nausithoë atlantica*, and illustrated here by the *Arcturus* specimen of *N. rubra*.

The sense organs, themselves, are of the usual coronate type. Unfortunately none of them are in good enough condition to show whether ocelli are present or not.

Gonads. The specimen is apparently a male, for surface views show the gonads crowded with sexual masses of various sizes and shapes; evidently not ova. As already noted, there are six gonads. All of these are fundamentally interradial with reference to the symmetry of the stomach. But while two of the interradial sectors have only one gonad each, each of the other two sectors includes a pair of gonads, so that these four are actually adradial in location.

The gonads, themselves, are irregular in outline. The four adradials are best described as roughly shield shaped, each of them incised, in outline, near the proximal end, on the side farthest from its fellow. One of the interradial gonads is roughly pentagonal, the other oval, and much smaller than the rest. The gonads are separated by considerable spaces in the perradii: but the adradial ones are in such close proximity in the interradii, that only slight growth would be required, to bring the members of each of these 2 pairs into contact with each other. And conditions in the related genus *Nausithoë* make it likely that this does actually happen at full maturity, at least in some specimens, if not in all. Distally the gonads of the present specimen extend outward to the edge of the muscular zone, but this may not be their final limit in that direction.

The base of the four-sided stomach is asymmetrical, corresponding to the radiality of the gonads, the two sides which have pairs of gonads opposite them being considerably longer than the 2 other sides, each of which has only one gonad abreast of it.

The aboral (basal) part of the gastric cavity, with its taeniola, and its relationship to the subumbrella, suggests the *Periphylla* type, rather than *Atorella vanhoeffeni*, or any of those members of the genus *Nausithoë* for which these structures have been fully described. Thus the base of the stomach is relatively voluminous, corresponding to the arched contour of the bell, and there are four deep, subumbrellar funnels (the so-called subgenital pits), penetrating, centripetally, nearly to the apex of the bell, between subumbrella and gastric wall. The corresponding ridges on the gastric floor, (the taeniola) are triangular in outline (Fig. 180); and the cirri which they bear thus form a cruciform figure, leaving vacant, at the apex of the dome, an area occupying about $\frac{1}{5}$ the diameter of stomach along its radius of curvature. The cirri are arranged in a single row of 10-12 along each edge of each of the taeniola, with a cluster at the tip. In this, as in the form and extent of taeniola and of subumbrellar funnels, *arcturi* (and apparently *Atorella subglobosa*, to judge from Maas' (1903, Pl. 3, Fig. 6) picture of the latter) resembles the more simply organized of the *Periphyllidae*, as represented by *Periphyllopsis* (Bigelow, 1909, Pl. 12, Fig. 1), more closely than the typical *Nausithoidea*; or than its close ally *Atorella vanhoeffeni*.

The distal portion of the gastric cavity (manubrium) is badly battered; such parts of it as still remain show that it extended at least to the level of the opening of the subumbrellar cup.

The condition of the specimen does not allow description of the distal canal system; except that (as usual, in this family) there is one broad radial pouch in the radius of each tentacle, and of each rhopalium. Presumably these are continuous, one with another, via a festoon canal, at the tips of the lappets. But I have not been able actually to trace this connection on the few lappets still present.

The ring-muscle is weak; the tentacular plates are not now apparent.

The preserved specimen is colorless, showing no trace of the deep reddish or brownish pigmentation which we have learned to associate with the bathypelagic habit, among scyphomedusae.

Family ATOLLIDAE.

Genus *Atolla*.

The history of the genus *Atolla* is typical, for the bathypelagic group of medusae, for as one deep sea expedition after another brought battered specimens to light, nine species, supposedly distinct, were proposed. But as greater numbers of specimens were studied, the number of these species was successively reduced, until it now seems likely, says Browne (1916), that all the *Atollas* which have yet been seen, represent variants, or contraction-phases, of two species only; *A. wyvillei* (the earliest named), with smooth lappets, and *A. chuni*, in which each of the lappets is studded with 7-9 small papillae.⁴ Even the sculpturing of the central lens; whether with or without radial furrows at its margin, with the degree of development and exact confirmation of these when present, is found, by Browne (1916), to be less reliable as a systematic character than previously supposed. And this conclusion is supported by the present series, which shows intermediates between the *bairdii* type, with smooth central lens; the *verillii* type in which the lens is scored with narrow radial furrows; and the *wyvillei* type where at least the edge of the lens is indented with broad radial notches, though its central portion may be smooth.

This character, then, goes into the same discard with most of the others which have been used to separate "species" of *Atolla*; relative breadth of the septal nodes for example, and the number of antimeres.

⁴ For a survey of the successive advances in our knowledge of this genus, see especially Haeckel 1880, 1881; Vanhöffen 1902; Maas 1904; Bigelow, 1909, 1913; Mayer, 1910; Broch, 1913; Browne, 1916.

It was long ago observed (Fewkes 1886; Maas 1897) that some Atollas, when taken, or after preservation, show a smooth anular zone between ring furrow and tentacular pedalia, which is not visible on surface views of other specimens. This difference, according to Vanhöffen (1902) represents merely a contraction- or compression-phase, for none of the *Valdivia* specimens of *Atolla* lacked this zone intermediate between coronal furrow and pedalia, though in some it was concealed by the everhanging margin of the central lens. Mayer (1910) has, however proposed the presence or absence of this zone anew, as a specific character, dividing the Atollas with smooth lappets into *bairdii* with it: and *wyvillei* lacking it. This supposed difference has not been discussed by later writers, and therefore demands a word of comment here.

No special attention was payed to this character in my study of the *Albatross* Atollas from the Eastern Tropical and Northwestern Pacific, beyond the fact that in most of them this zone was concealed (Bigelow 1909, Pl. 9, Fig. 3, Pl. 10, Fig. 9). Reëxamination of some of these specimens gives the following results.—Out of 8 specimens, in fair condition, from off Japan ("Eastern Sea," Albatross Station 4907), 30–65 mm. in diameter, seven have the central lens overhanging, and nearly entirely concealing the anular zone, while in one specimen the central lens is much more elevated, leaving the edge of this zone visible, in aboral view.

Two out of three excellent specimens from Bering Sea, Albatross Station 4766, with disc very flat and firm, show no distinct intermediate zone, in aboral view, their pedalia seemingly separated from the margin of the central lens only by the coronal furrow. The third, in equally good state, shows an intermediate zone much narrower than the length of the tentacular pedalia.

As a radial section though the bell of this last specimen shows, the coronal furrow is very deep when this intermediate zone is nearly or quite concealed: deeper, in this case than the length of the tentacular pedalia. And the connecting zone below it, between central lens and peripheral zone, is narrow. Another much flattened specimen, also from Bering Sea (Albatross Station 4773), about 35 mm. in diameter, also has the central lens practically in contact with the pedalia. And among the Atollas which I have examined such has been the condition in general, in the specimens in which the gelatinous substance was firmest, the bells flattest, and the

pigment most nearly intact after preservation, i. e. in those that were probably alive when placed in the preservative, and so may be supposed to have suffered muscular contraction. This same state is shown by Vanhöffen (1902, p. 5, Fig. 24).

Two other specimens from this same station, respectively of 35 and 45 mm., with the central part of the disc more elevated, and the gelatinous substance softer, show intermediate zones between ring furrow and pedalia, nearly as wide as the latter.

The great majority of the large *Arciurus* specimens, listed below, illustrate a still more relaxed state, with the whole medusa softer and more cup shaped, the central lens bulging higher above the level of the ring furrow, the marginal zone hanging downward, and the smooth intermediate zone about as broad as the tentacular pedalia are long: in some cases even broader.

Radial sections of specimens of this type show the basal connecting zone at the bottom of the coronal furrow, between periphery (corona) and central disc, relatively thicker ($\frac{1}{3}$ - $\frac{1}{2}$ as thick as the coronal furrow is deep) than is the case when the smooth annular zone is less prominent; furthermore, in such specimens the relaxed annular zone is much softer in texture than the pedal zone.

As has long been known, this connecting zone is the site of a circumferential strand of contractile fibres; and complex series of such fibres are imbedded in the gelatinous substance of *Atolla*.

In short, the apparent presence or absence of the smooth annular zone, has no genetic significance in *Atolla*. Every gradation is to be found (among specimens in different state of contraction or relaxation) from those in which no such band can be distinguished, other than the smooth outer wall of the coronal furrow, to others showing a protruberant band of this sort, as broad as the pedalia are long and which may or may not be marked off from the latter by a furrow.

Such differences do not indicate the existence of varieties, but reflect nothing more than the state of the animal—whether still alive, or dead and flaccid—when placed in the preservative, or the amount of muscular contraction it may have experienced, in the latter.

All of the *Atollas* in the present series (all have smooth lappets where these are intact) are therefore referred to the oldest named species, *A. wyvillei*. Notes on their condition, as regards the

annular zone, and the radial notching of the central disc, will be found below.

Atolla wyvillei, Hackel.

Atolla wyvillei, Haeckel, 1880, p. 488; 1881, p. 113, pl. 29, fig. 1-9.

Synonymy, see Mayer, 1910, p. 563, 565, 567 ("*A. bairdii*," + "*A. valdiviae*" + "*A. gigantea*" + "*A. wyvillei*").

Station 33, 700-0 fathoms; 2 specimens, in fair condition, one about 95 mm. in diameter, fully relaxed and with central lens showing only faint notching at the margin; the other, 38 mm. in diameter, flattened, and contracted, so that the intermediate zone is concealed in the coronal furrow, and with central lens deeply notched with narrow furrows at the margin.

Station 39, 250-0 fathoms; 2 specimens, about 10 and about 20 mm. in diameter, in poor condition.

Station 50, 1200-0 and 400-0 fathoms, 2 specimens about 21 and about 25 mm. in diameter, both fragmentary and relaxed, showing intermediate annular zone; one with smooth, the other with slightly notched central disc.

Station 59, 600-0 fathoms, 6 specimens, 20-35 mm. in diameter, all soft and fragmentary.

Station 68, 600-0 fathoms, 1 specimen, 90 mm. in diameter, relaxed; shallow indentations at margin of disc; annular zone as broad as pedalia are long, and demarked by narrow lines of pigment.

Station 74, 600-0 fathoms, 7 specimens, 17 to about 85 mm. in diameter; all soft, and more or less fragmentary. Most of these show a broad annular zone; but in the two best (40 and 35 mm.), the notched margin of the central disc conceals all but its outer edge, so that these specimens are precisely intermediate between the *Bairdii* and the *Wyvillei* types.

Trawl hauls from 625 and 749 fathoms also yielded 6 more, of 30 to 100 mm., somewhat damaged, and soft, of the *Bairdii* type, some with traces of furrows at the edge of the disc.

Station 84, 400-0 fathoms, fragments of one small specimen. 700-0 fathoms, 2 specimens of about 38 mm., much damaged; both of these show narrow annular zone, combined with narrow radial furrows at the edge of the central disc.

Station 86, 400-0 fathoms: four specimens, 80-100 mm., somewhat damaged, but all showing the annular zone. In two the central disc is perfectly smooth: in two it is slightly notched at the margin. 1000-0 fathoms, four specimens, 38 to about 76 mm. in diameter; all with broad annular zone showing; 3 with smooth disc; one with the disc showing traces of radial notches at its margin.

Station 100, 1098-0 meters, one 14 mm. in diameter, fragmentary. 2192-0 meters, fragments.

Station 105, 500-0 meters, one, about 20 mm. in diameter, fragmentary; 600-0 meters, one, of about 26 mm. with perfectly smooth disc, and poorly defined annular zone.

Station 108, 600-0 meters, one, about 43 mm. in diameter, in fair condition with broad notches at margin of disc only; and narrow but sharply defined annular zone.

Station 113, 500-0 meters, 2 specimens, 23 and 30 mm. One shows broad notches at the margin of the lens, and annular zone about as broad as the pedalia. The other has narrow radial furrows at the margin of the disc, and the annular ring is covered and concealed by the latter. These are intermediate between the *Bairdii* and *Wyvillei* types. 900-0 meters, one of about 20 mm. very fragmentary. 1200-0 meters; one, of about 85 mm. in good condition. The margin of the disc shows traces of radial indentations; the annular zone is very prominent and broader than the tentacular pedalia are long; *Bairdii* type.

Among 10 specimens taken at random, 3 had 21 tentacles; 3 had 22; and 4 had 24, with corresponding numbers of marginal sense organs. None of the specimens are in good enough condition to add anything to previous knowledge of the anatomy of this genus. Most of the captures (stations 33-86) are from the Equatorial Pacific, in the Galapagos-Cocos. I., region, where the expeditions of the *Albatross* 1891 and 1904-1905 had already proved *Atolla wyvillei* widespread (Maas, 1897; Bigelow, 1909, Pl. 48). The list also includes four Atlantic stations; one a few miles south of Bermuda (Sta. 100); one in the offing of Cape Hatteras (Sta. 105); one (108) just outside the continental slope, off Chesapeake Bay; and one at about the same relative position in the offing of New York.

Atolla has been taken at many stations in the Eastern North Atlantic, as well as along the continental slope in the offing of the coast sector, Cape Hatteras—Cape Cod. These *Arcturus* records are, however, of considerable faunistic interest, because the *Bache* failed to find a single *Atolla* in the oceanic triangle Chesapeake Bay—Bermuda—Bahamas during the winter of 1914, although numerous tows were made down to 1000 meters (Bigelow, 1918, P. 434).

With many summer records for that general region,⁵ none for winter, a seasonal periodicity for *Atolla* in these comparatively high latitudes is suggested, with the maximum abundance in summer and early autumn. Until it is known whether *Atolla* is holoplanktonic, or whether, like many scyphomedusae, it passes through a fixed stage in its early life, such a periodicity is difficult to interpret. And in equatorial waters we have, as yet, no evidence of any such fluctuations in its abundance with the change of the seasons.

The *Arcturus* records are also instructive, bathymetrically. The shoalest Pacific capture was from about 500-0 meters. And so many shoaler tows were made during the expedition, that *Atolla* can hardly have occurred shoaler than about 500 meters in the Galapagos region at the time, unless accidentally. The shoalest Atlantic records, for the *Arcturus* series, are also 500-0 meters: and the same reasoning applies. When an *Atolla* is occasionally taken at the surface, this represents a sporadic excursion upward, out of its normal habitat.

Family LINUCHIDAE.

Genus *Linuche*.

These small, thimble-shaped medusae are among the most familiar of their tribe in West Indian waters and in the neighboring

⁵ All Fewkes, and Broch's records are for the months of June—November.

parts of the Atlantic; equally widespread, too among the Malaysian archipelago. And they have repeatedly been described and pictured. Nevertheless, their wide variability, individual and swarm, makes it still an open question how many subdivisions of the genus deserve the rank of species.

At one time or another, nine such have been named, and four genera. But recent students have condensed these to two at the most, the interrelationships of which still remain puzzling. These are the small, brownish-tinted *L. unguiculata* (perhaps separable into two recognizable races), and a larger green form, for which Thiel (1927) has recently revived Haeckel's (1880) name *draco*, which had previously been relegated, by Mayer (1910), to the synonymy of *unguiculata*.

Mayer (1910) believed that, in the *unguiculata* group, a pacific form (*aquila*) could be distinguished from an Atlantic (*unguiculata*) by the arrangement of the subumbral pouches. And Stiasny (1924) has recently recorded *Linuche* from Malaysia as *L. unguiculata* var. *aquila*. Vanhöffen (1913), however, by his discovery of the supposedly Pacific variety as well as of the supposedly Atlantic, among *Linuche* from the Tortugas, Florida, proved that the two are not separated geographically. This Thiel (1927) substantiates by again finding Atlantic specimens (from Hayti) showing the arrangement of subumbral sacs which Mayer (1910) had thought typical of the Pacific *aquila*. This according to Thiel, indicates the co-existence in the Atlantic of two distinct forms of *Linuche* of the *unguiculata* group, either varieties (*aquila* and *unguiculata*) of one species, or possibly distinct species. But the great variability in the number and in the radial location of the subumbral sacs of the *Acturus* series, and of other specimens in the Museum of Comparative Zoology, described below, tends rather to support Vanhöffen's (1913) explanation of the difference between *unguiculata* and *aquila* as due, simply to individual variation. They are therefore united here, following him, under the older of the two names. I have had no opportunity to study the form recorded by Thiel (1927) as *L. draco*.

Linuche unguiculata (Schwartz).

Medusa unguiculata, Schwartz, 1788, p. 195, Taf. 6, Fig. 1.

Synonymy see Mayer, 1910, p. 558 ("*L. unguiculata*"), 560 ("*L. aquila*");
Vanhöffen, 1913, p. 429.

Station 69, near Cocos I., May 14, 1925. Depth?, 4 fragmentary specimens, all about 6 mm. high.

Station 96, southeast of Bermuda, July 11, 1925: surface. 43 specimens in fair condition, 6- about 10 mm. in diameter, with the gonads in various stages of development. All appear to be females.

Although the general organization of *Linuche unguiculata* is well known,⁶ the present collection offers an opportunity to add some details as to the arrangement of the subumbrel sacs, the growth of the gonads, and as to the color patches (so conspicuous a feature of the subumbrella, in life), which are now known to be due to infestations of yellow or brown Algal cells, not to pigment produced by the Medusa itself (Thiel, 1927).

The subumbrel sacs. These curious pouch-like diverticula, hanging into the bell-cavity from the oral walls of the radial pouches, characterizing the family, are so conspicuous that they have figured in most of the published descriptions. But there has been some confusion as to their radial arrangement and number.

The most recent pictures of West Indian *Linuche* (Mayer, 1910, P. 59, Fig. 7, and P. 560, Fig. 356A) show three concentric rows of these sacs; an innermost (of 8) per radial and interradial with respect to the radially of the stomach: an intermediate row also perradial and interradial so that they alternate with the 8 arms of what are originally 8 separate adradial gonads; and an outermost row of 32, two of them to each radial pouch. On Pacific specimens, however, Mayer (1910, p. 560, Fig. 356b) found only 2 rows, the inner of 16, 4 of them perradial, 4 interradial, and 8 adradial, i. e. in the radii of the gonads and interrupting the latter midway of their length.

The *Arcturus* series, and also series in the collection of the Museum of Comparative Zoology, from Florida and from Fiji, are all essentially of the Pacific type so far as the radial arrangement of these pouches is concerned, though the number of concentric rows may be either two or three, while the relationship of the sacs to the gonads alters with the growth of the latter.

In young specimens with small gonads (exemplified by the *Arcturus* specimens from station 96, Fig. 182) the arrangement is as follows:—1) an outermost row of 32, two to each radial pocket, situated just centripetal to the band of circular muscle fibres; 2) an intermediate row of 16, consisting of one large sac at the tip of each gonad (adradial), 4 others perradial and 4 interradial; and 3) the innermost row, represented by 4 small interradial sacs close to the margin of the stomach.

Only one of the 4 Pacific specimens from Station 69 is in good enough condition to show the arrangement of the sacs. In this one the outer and intermediate rows are as just described (the adradial members of the latter in contact with the tips of the gonads). But the innermost row is represented only by a very small sac in one of the interradia.

This basic arrangement is shown (Fig. 182). All the specimens which I have examined show this same radial arrangement of the intermediate row, namely 4 perradial, 4 interradial and 8 adradial; but there is much variation with regard to the innermost row.

Among slightly larger Atlantic specimens collected by the *Bache*, for ex-

⁶ See Mayer, 1910, for a good general account.

ample (Bigelow, 1918), one with gonads of medium size (Fig. 183) has perradials as well as interradians in all three of the rows of sacs, with adradials in the outermost and in the intermediate rows, making a total of 56. And this seems to be the maximum number ever attained. But others among this same series have only 2 rows in the perradii with 3 in the interradii, agreeing in this with the *Arcturus* series.

A collection of large adults from Palm Beach, Florida, from Dr. Thomas Barbour, increases the range of variation, for while one has the innermost row of sacs represented in the interradii (but not in the perradii), most of the specimens lack this row altogether. And another, with large gonads (Fig. 184), not only lacks the innermost row, but also the adradial members of the inter-

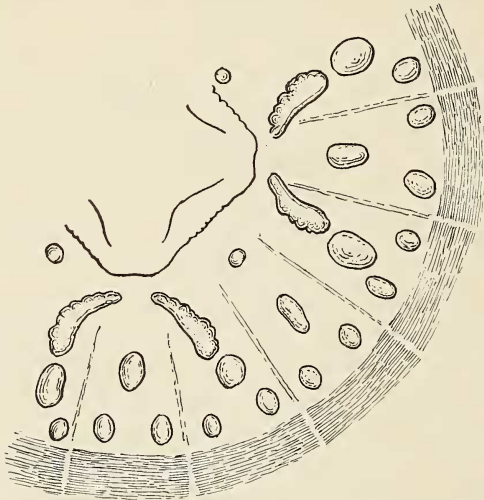


Fig. 182. *Linuche unguiculata*; portion of subumbrella, to show relative positions of gonads and of subumbrellal sacs in a specimen about 8 mm. in diameter, from *Arcturus* Sta. 96.

mediate row. The total of only 40 sacs, in this example, is the smallest number so far found in any adult specimen.

Thus the collections which I have examined corroborate Vanhöffen's (1913) conclusion that no distinction can be drawn between the Atlantic and the Pacific representatives of *Linuche*, with regard either to the number of concentric rows in which the subumbrellal sacs are arranged, or with regard to their number.

According to Maas (1903), in the Malaysian specimens collected by the Siboga Expedition, the sacs are differentiated from the rest of the subumbrella by a thickening of the ectoderm. This, however, seems to have been a misapprehension, based on surface views. Serial sections show that the pavement-

like ectoderm is no thicker in the sacs than elsewhere, but that it is underlain there by a layer, several cells thick, of the "yellow cells" (p. 514).

Haeckel (1880), misled perhaps by the superficial resemblance which these closely crowded yellow cells, in poorly preserved material, bear to the male sex cells of other medusae,⁷ suggested that the sacs might be the male gonads. This, however, was disproved long ago (Maas, 1903.) But while the

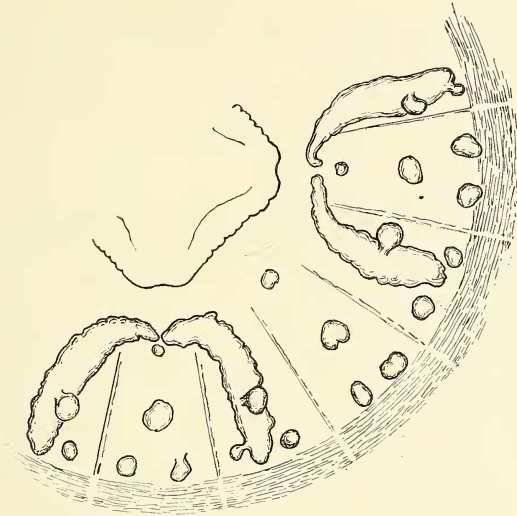


Fig. 183. *Linuche unguiculata*; portion of subumbrella of Atlantic specimen 11 mm. high, to show gonads and subumbrellal sacs (M. C. Z., No. 3076).

sacs may be assumed to have to do with digestion or, as Thiel (1927) suggests, with respiration, their true function still remains unknown.

Gonads. In young specimens, about 3-5 mm. in diameter, collected by the *Bache* between Florida and the Bahamas (Station 10203) in March, 1914 (Bigelow, 1918, P. 401) the gonads are already visible as 8 separate oval thickenings of the entoderm in the oral gastric wall, arranged in pairs, one in each of the adradial pouches, close to the margin of the stomach. This corresponds to the stage illustrated by Mayer (1910, P. 59, Fig. 5) for an *Ephyra* 4 mm. in diameter, and thought by Haeckel (1880) to characterize the genus *Linuche*. With growth the members of the pairs of gonads which flank each perradius become curved, their concavities toward each other, while still separate at their centripetal ends. And most of the *Arcturus* specimens are in this stage.

With continued growth (genus *Liniscus* of Haeckel) the centripetal ends of the members of each pair of gonads come together in the perradii, resulting

⁷"In einigen Fällen waren die Säckchen dicht gefüllt mit sehr. kleinen rundlichen Zellen, welche dieselbe Grösse wie die unreifen Sperma-Zellen anderer Medusen hatten." (Haeckel, 1880, p. 493.)

in four horse-shoe shaped figures, the arms of which extend outward along the adradial pouches. At the same time the gonads grow centrifugally, surrounding the adradial members of the intermediate circle of subumbrel sacs, and reaching outward until their outer ends closely approach, or touch the outermost circle of sacs. Most of the *Bache* specimens from Station 10203, (females) just mentioned, exhibit this stage, as did the Pacific *Linuche aquila* figured by Mayer (1910, P. 560, Fig. 356 C).

All of these, and such of the *Arcturus* series as have been sectioned, besides large adults from Fiji in the collection of the Museum of Comparative Zoology, are females, with large ova in various stages in development. And it is not known whether the gonads of this sex (easily recognizable as female at maturity by the folded and frilled appearance of the gonads as seen in surface view) grow larger than this: in fact this stage is farther advanced than most of the adults that have previously been figured. But ripe males from Palm Beach, Florida, collected by Dr. Thomas Barbour,⁸ have still larger gonads (Fig. 184); these having grown out beyond the outer circle of subumbrel sacs, making the neighboring members of the latter seem like outgrowths from the margins of the gonad-arms. On some of these specimens the gonads reach just to the inner edge of the zone of circular muscle fibres, and at their inner ends are closely apposed in the perradii but show no signs of approaching each other in the interradii. On other examples the gonads reach out part way across the muscular zone (visible right through the muscle fibres, even in oral views of preserved specimens, both stained and unstained), while at their inner ends lobar outgrowths toward the interradii narrow the intervals between them. And in one example the gonads not only reach right across the muscular zone, to the bases of the marginal lappets, but their proximal ends have come into contact with one another in the interradii as well as in the perradii (Fig. 184), corresponding to Haeckel's (1880) genus *Linanthæ*.

In the males of *Linuche*, unlike the females, the surfaces of the gonads are smooth, so that in the adult stage these organs superficially resemble those of certain Trachomedusae: *Halicreas* in particular.

Colored Patches. The presence of deeply colored spots or patches of brown, yellow or green, on the subumbrella of *Linuche*, has been mentioned by most of the authors who have written of the genus, though their true nature seems not to have been understood, until very recently. Thus Haeckel (1879, pl. 29, Fig. 6; 1880, p. 492) interpreted the opaque patches by which they are represented in alcoholic specimens, as areas of union between the exumbrel and subumbrel walls of the radial pouches. Fewkes (1882, p. 260), speaks simply of the subumbrella of *Linuche* as "thickly pigmented." And Mayer (1910, p. 559), speaks of the brown color as "numerous, separated, more or less polygonal areas of digestive cells in the gastric pouches."

Thiel (1927), however, has now shown that in reality these patches, both in *L. unguiculata* and in *L. draco*, reflect the presence of algal cells, corresponding to the so-called yellow cells or zoochlorellae of various other coelenterates. And this I can corroborate from microscopic sections of the present series. These "yellow cells" are oval or spherical in outline, about .006-.007 mm. in

⁸ Curiously enough, surface examination has revealed no females among this series.

diameter, with definite cell wall, granular contents, deeply staining nucleus, and usually with one pale-staining area. Among them, various stages in division are to be seen. Thus they very closely resemble, both morphologically and in their mode of reproduction, the corresponding structures in *Cassiopea*, the vegetable nature of which was demonstrated by R. P. Bigelow (1900).

To find these algal cells in *Linuche* is, of course, in no way remarkable: witness their well known presence in many Rhizostome medusae, as well as in Actinians, Hydrocorallids, Alcyonarians, etc. So far as I am aware, however, they have not been reported in any others of the Coronatae, or among Saemostome medusae.

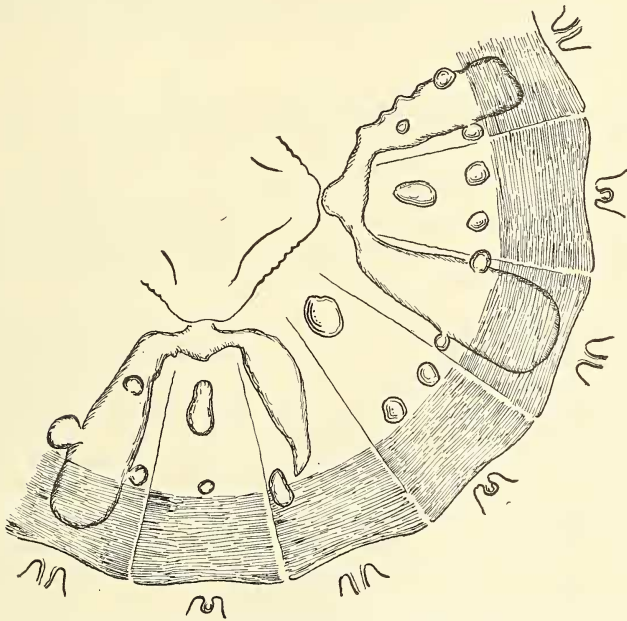


Fig. 184. *Linuche unguiculata*; portion of subumbrella of Florida specimen about 12 mm. in diameter, with very large gonads.

In the *Arcturus* specimens, the colored patches (119 in one specimen) are scattered around the periphery of the subumbrella, distal to the outer circle of subumbral sacs, 2-5 in number per radial pouch, and extending out into the marginal lappets, each of which also has 2-5 patches. Usually the patches are roughly oval, or sausage shaped, often two in contact: and individual patches may be bifid. The yellow cells are situated in the oral wall of the radial pouches, next to the muscular layer, or to the mesogloea, in a layer several cells deep, as described by Thiel (1927). The endodermal epithelium between these patches

in this zone, is composed of a single layer of flat pavement-like cells. And although the histologic fixation (in formalin) is not of the best, fragments of the endothelium can be discerned here and there, enclosing the "yellow cells": evidence that the latter multiply between the entoderm and the mesogloea, or muscular layer as the case may be.

In the specimens examined from Station 96 no yellow cells were to be seen in the interspaces between the patches, or in the subumbrel wall between the latter and the gastric sacs. But they infest the entoderm of the latter, in a layer several cells deep: it was here in fact, that Thiel (1927) recorded them, and that Haeckel (1880, p. 493) had long ago seen them, though without realizing their true nature (p. 513). In several cases masses of the yellow cells were found intruding from a subumbrel sac into the lumen of the neighboring part of the radial pouch, but this may be the result of the poor fixation of the material.

One, at least, of the Pacific specimens from Station 69,⁹ shows a more extensive infestation, with the patches of yellow cells in the outer part of each radial pouch confluent, so that the whole oral surface from the muscular zone out to the tips of the lappets, is involved, except for very narrow pale lines, mirroring the demarkation between the discrete yellow patches of an earlier stage in development. In this specimen, too, the inner (centripetal) parts of the pouches are also infested, each with one or two large, angular patches, separated from the distal infestation by only a narrow band, just distal to the outer circle of subumbrel sacs.

In slightly larger specimens from Fiji (also females) cross-sections and surface views show the yellow cells spread over the whole subumbrel surfaces of the radial pouches, from their proximal ends, outward to the edges of the lappets, including the subumbrel sacs. In the region of the muscle zone, a polygonal subdivision of the infestation by narrow lines, suggests that at a younger stage, the yellow cells had been in separate patches. And these subdivisions appear as pale bands in Mayer's (1910, pl. 59, Fig. 11) painting from life of one of this same Fijian series.

In the localization of the yellow cells in the entoderm, perhaps also extending into the lumina of the radial pouches, *Linuche* agrees with *Cotylorhiza* among the rhizostomes (Mayer, 1910) and differs correspondingly from *Cassiopea*, in which they are most plentiful in the mesogloea of the umbrella, though occurring to some extent in the entoderm also (R. P. Bigelow, 1900).¹⁰

Color. The *Arcturus* specimens (in formalin) now show a pale brownish tinge: no notes as to their color in life are available.

Geographical distribution. The range of *Linuche unguiculata* is restricted to tropical and subtropical waters, but includes all three great oceans; chiefly, however, near land. In the Atlantic it is widespread and abundant in the Floridan-West Indian-Bahaman-Caribbean region generally, and in the Gulf

⁹ The others are not in good enough condition to show the limits of distribution of the yellow cells.

¹⁰ For a further discussion and illustrations of the yellow cells of *Linuche*, see Thiel, 1927.

of Mexico. The Bermudas seem also to be a center of production for it; witness the *Bache* record about fifty miles to the northwest of that group; (Bigelow 1917, chart, Station 10176); likewise the *Arcturus* captures 270 odd miles to the southeast (Station 69). In the eastern side of the Atlantic *Linuche* has been taken at the Cape Verdes, and thence southward, at various localities, along the west coast of Africa, to Angola.

In the Pacific it is known from the Gallapagos—Cocos Islands region in the east; from many localities in the South Seas; from Australia; from the Malaysian region; and from the neighborhood of Madagascar in the Indian Ocean.

On the whole it may be described as neritic in habit, suggesting that it passes through a fixed stage in its development. But there is a gap in our knowledge of its life history between the Planula stage (described by Conklin, 1908), and the young medusa.

Order DISCOPHORA.

Family PELAGIDAE.

Genus *Pelagia*.

Pelagia offers the interesting case of a genus, distinguishable from its relatives by precise and easily definable characters, but including a whole series of forms, the precise significance of which it has not yet been possible to determine. Certainly these forms, varieties or races, are not species in the sense in which this term is usually defined: not only are the extremes connected by unbroken series of intermediates, but they can not be correlated with geographic distribution. We have here, as Mayer (1910, p. 571) remarks, one of those instances—not uncommon among medusae—where the Linnean System of classification is inadequate to express the relationship of the numerous closely related forms. If we are to use this system, it is reasonable to demand that species shall be recognizable; i. e. that the characters chosen to characterize them shall be such that at least the great majority of specimens can be referred definitely to one species, or to another: or, if the status of any considerable number of specimens be plotted graphically, the resultant figure must partake of the nature of a dumb-bell, not of an ellipse, before we can speak of distinct species; even of subspecies. If the intermediates prove to greatly outnumber the so-called "species," the classification breaks down. And this is just what has happened, in *Pelagia*, as one system after another has been subject to critical examination.

A brief statement of the several characters which have been so

tested will make this clear. The earlier students of the group devoted attention chiefly to the proportionate dimensions of bell, manubrium and mouth arms; to the outlines of the marginal lappets; and to the number, conformation and arrangement of the exumbrel nettle warts. And at least 18 supposed species or varieties (and perhaps more) have been founded on these characters, separately or in various combination.

Large series of measurements, by Vanhöffen (1902); Broch (1913); Kramp (1924) and Bigelow (1913), have, proven, however, that there is no discontinuity between specimens (or varieties) with relatively long, and those with relatively short, mouth arms, or manubrium. These proportions as Broch (1913) demonstrated, alter with age; the manubrium being shorter, relative to the mouth arms, in large medusae than in small. Similarly Kramp (1924) found no consistent difference in relative length of the mouth tube between Mediterranean and Atlantic Pelagias, except that it may average slightly longer in the former, which is directly contrary to earlier accounts. Neither did proportionate measurements, of themselves, give warrant for distinguishing more than one species among all the specimens from the Atlantic, Indian and Pacific Oceans, gathered by the *Valdivia* and by the *Albatross*.¹¹

The *Albatross* and *Arcturus* specimens substantiate Vanhöffen's (1902) observation, latter corroborated by Broch (1913), and by Kramp (1924), that the precise conformation of the exumbrel warts has no greater diagnostic value. Browne (1916, p. 204), it is true, following Mayer (1910), believes that these warts "will yet prove useful for distinguishing races, if not species." But the *Valdivia* collection showed intermediates between the elongate warts of *noctiluca* and the rounded of *panopyra* (Vanhöffen, 1902). Broch (1913) found, among the large Atlantic specimens collected by the *Michael Sars*, all the different varieties of these warts, which have been used as specific characters. Kramp (1924) also found the warts highly variable in size, and shape, with no discontinuity between Mediterranean and Atlantic specimens, and with a tendency for large specimens to show more elongate, and larger warts than small; often with several coalescing in a row, which the specimens I have myself examined, corroborate. As I have previously remarked (1913, p. 89), large specimens invariably (in my experience)

¹¹ See Vanhöffen, 1902, Bigelow, 1909, 1913.

bear warts of various forms, ranging from round to oval, often linear; of various sizes; they may be more or less prominent; and either subdivided by transverse furrows, or smooth surfaced. In small specimens the warts usually—perhaps invariably—take the form of rounded knobs, and they are proportionably higher in small medusae than in large ones. Furthermore, Kramp (1924) has pointed out that the warts alter in shape, with contraction. It is likely, too, that they also alter, if any of the nematocysts be discharged under normal conditions. And they are more or less prominent according to the state of nourishment of the medusa.

The precise outlines of the marginal lappets has also been found so variable as to be worthless for specific characterization; in fact Kramp (1924) found lappets of different shapes on a given individual.

The only reasonable conclusion, from the evidence summarized above, is that one species of *Pelagia*, at any rate, occurs, widespread, over the warmer parts of the Indian and Pacific and Atlantic oceans, as well as in the Mediterranean. This, in fact, is just what was to be expected from analogy with other holoplanktonic medusae. To this species the oldest name—that of the Mediterranean form (*P. noctiluca*) must be applied.

It seems impossible—in the present state of our knowledge—to separate any of the other named species of the genus from this combined oceanic form; *noctiluca*. Even the three *Pelagias* recently described as new by Stiasny (1914, 1922), *P. purpuroviolacea*, *P. rosacea*, and *P. curaçoensis*, all fall well within the range of variability of *noctiluca* as represented by the series collected on the high seas by the various deep sea expeditions. In fact, Stiasny (1924a, p. 84), himself states (corroborating earlier students) that the relative length of manubrium and mouth arms is unreliable, and that the nettle warts are not only of different shapes on different parts of the bell of a different individual, but change with age.

Pelagia noctiluca, Forskål.

Medusa noctiluca, Forskål, 1775, p. 109.

Station 26, Surface, 20 specimens, 7–70 mm. in diameter: 100–0 fath., 5 specimens 33–40 mm. in diameter.

Station 31, 500–0 meters, 22 species, fragmentary, 30–50 mm. in diameter.

Station 57, Surface, several specimens, 4–7 mm. in diameter.

Station 59, 300–0 fathoms, fragments. 500–0 fathoms, about 75 juveniles, 3–5 mm. in diameter.

Station 74, Surface, 2 specimens, 14 and 16 mm. in diameter. Closing net, 500–300 meters, one specimen, 23 mm. in diameter.

Station 98, 300-0 meters, 1 specimen, 8 mm., in diameter.

Station 100, Surface. 5 specimens, 4 of them 5-10 mm., one 60 mm. in diameter. Also between Stations 96 and 97, southwest of Bermuda, surface, 4 specimens, 50-70 mm. in diameter.

From the systematic standpoint the *Arcturus* collection is interesting chiefly as cumulative evidence to the effect that no specific distinctions can justly be based on the shape of the exumbral nettle warts, which show all possible gradations from round and dome shaped, to linear and ridge like. In all our small ones, they are of the former type. On a medium sized specimen most of the warts are round to narrow-oval (*perla* and *panopyra* types). Among the 4 large specimens of 50-70 mm. from the Atlantic, rounded to oval warts dominate in one; high, narrow and ridge like warts characterize the other three. And of these last, one has the marginal zone smooth (*cyarella* type), while in the other the margin, as well as the centre of the disc is warty (*noctiluca* type).

Most of the specimens have suffered so much in the preservation, that measurements of mouth arms and manubrium would be of little value. Certainly most of them fall well within the limits given by previous students.

The chief interest of the series is its demonstration that *Pelagia*, usually regarded as a surface medusa, may sink to a considerable depth: witness the capture of one in a closing net at least as deep as 300 meters (station 74). And this, it seems, is the greatest depth at which the presence of *Pelagia* is definitely established. It is also probable that the specimens from station 59 came from a considerable depth, because surface tows yielded none there. The captures are from the Gallapagos-Panama region, and in the Atlantic from the general vicinity of Bermuda, regions where *Pelagia* has already been recorded.

Family CYANEIDAE.

Genus *Cyanea* Linné.

Cyanea capillata, var. *fulva* L. Agassiz.

Medusa capillata, Linné, 1758, p. 660: *Cyanea fulva*, L. Agassiz, 1862, p. 119, 162.

Synonymy, Mayer, 1910, p. 596, 600.

One specimen, about 140 mm. in diameter, labelled "surface in the Gulf Stream July 25, 1925," which locates the capture in the offing of New York some 10 miles outside the continental edge as outlined by the 100 fathom contour.

This specimen is referable to the small yellowish variety (*fulva*), of the species, representative of the genus *Cyanea* along the middle Atlantic States, by its color (pale yellowish brown in formalin), and by the fact that the gonads are well developed at so small a size.

Stiasny's (1919-1922) recent studies of Atlantic and Indo-Pacific Cyaneas have brought out fresh evidence of the extraordinary tendency which this Scyphomedusa shows, to break up into environmental races, over its broad range. Whether any of these more or less recognizable forms deserve to be dignified with the name of species, as distinguished from the oldest known, *C. capillata*, of the North Atlantic and North Pacific, is still an open question. On the basis of such information as is yet available, it still seems wisest to class

all of them as varieties of *C. capillata* (Bigelow, 1913), for they are connected by intermediates, not only with respect to color, but also with respect to the several anatomical characters (marginal outlines of the lappets; number of tentacles; stage of development of gonads at different sizes), by which the extreme forms are separable.

At any rate it seems certain that all the Cyaneas that have yet been described from the east coast of North America must be so regarded, a very large, and deeply colored variety (*arctica*) prevailing to the northward of Cape Cod, giving place to smaller and paler Cyaneas off the middle (var. *fulva*) and south Atlantic United States (var. *versicolor*).¹²

Stiasny (1921) has recently demonstrated, by injection, that the tentacular and rhopolar radial pouches of his new varieties *Mjobergi*, and *Buitendijki* from Australia are connected in the muscular zone by many cross anastomoses, instead of being separated by continuous septa, as was formerly thought characteristic of the genus. And he suggests that, by proper methods of examination, this may perhaps be found the case in some of the northern varieties, as well. Unfortunately the rather fragmentary state of the *Arcturus* specimen has made it impossible to test this by injection. But surface views of dissections of the marginal zone so strongly recall Stiasny's (1921) figures of this anastomosis, and in just the same region (i. e. in the zone of the circular muscles), that its occurrence in the Atlantic var. *fulva* seems altogether probable, if not definitely proven.

There is nothing remarkable in the capture of an odd example of this neritic medusa over the continental slope in the warm saline water of the so called Gulf Stream at this latitude, for this variety of it is known from southern New England to the Carolinas. In July, 1913, for example, the *Grampus* had it at four stations in the coastal sector between New York and Chesapeake Bay (Bigelow, 1915, P. 317); at five stations between the offings of Delaware and Chesapeake Bays in August 1916 (Bigelow, 1922, P. 159).

Offshore records of this genus are always interesting, Cyanea, strictly of shoal-water origin, being one of the best of natural drift buoys to show expansions of coastal water. In the present instance, however, we lack the record of temperature and of salinity which would have shown whether the specimen was drifting southward, just inshore of the zone of contact between banks and oceanic waters, by the track followed by many drift bottles (Bigelow, 1927, P. 882), or whether it had actually crossed this zone, and had been picked up by the Gulf Stream drift toward the northeast. Judging from general knowledge of ocean dynamics along the North American seaboard, the first of these alternatives seems the more probable.

¹² For description of these, see Mayer, 1910.

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